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DAMPNESS IN BASEMENTS AND GROUND FLOORS *

by

Richard S. Dill and Douglas E. Parsons

CONTENTS

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* Causes and remedies for dampness in walls above the ground are discussed in LC 721, "Dampness in Masonry Walls Above Grade", obtainable from the National Bureau of Standards, Washington 25, D. C.

I. INTRODUCTION

Basements as ordinarily constructed are not proof against the passage of moisture from the outside and the condensation of moisture on the wall and floor surfaces when the conditions of exposure are unusually severe. In other words, most basements would leak if subjected for long periods to water under pressure, would allow moisture to be drawn through the walls and floor if kept in contact with saturated soil, and would be damp during warm and humid weather if surrounded by cool earth. In most cases, however, the natural drainage and climatic conditions are such that a high degree of resistance to water penetration and a large amount of thermal insulation are not needed to prevent excessive dampness in basements.

The use of the basement should determine whether or not the expense of providing safeguards against dampness is warranted. Visible moisture on walls and floors is always objectionable but the amount of dampness which may be considered allowable varies. For example, if the basement is to serve only as a storage space for vegetables or fuel, occasional dampness would not be as objectionable as if it were to be used for recreation or living quarters.

The most inexpensive method of building a basement that will be satisfactorily dry or of eliminating dampness in an old one will depend therefore upon the value of the space made usable thereby and such factors as the natural drainage and climate. A study of the site and an understanding of the causes of dampness are essential for the selection of a satisfactory safeguard or remedy.

II. CAUSES OF DAMPNESS AND METHODS OF DETERMINING THE SOURCES

Dampness in basements and ground floors may result from three causes: (1) condensation, (2) penetration of water by leakage through openings or joints in walls and floor, and (3) penetration by capillary transmission of moisture through masonry or concrete from damp soil. The cause must be determined before the remedy can be selected.

Leakage through openings or joints in the walls and floors is easily detected. Water usually begins to flow or seep through openings during a heavy rain, but may not appear until after several days of wet weather. If leakage is the only cause, the basement will be dry during periods of prolonged drought or even after occasional light rains, regardless of the temperature or humidity of the outdoor air.

Capillary transmission of moisture through the floor and walls is most noticeable when the soil under and around the basement is wet and the rate of evaporation inside the basement is low. In the absence of leakage through openings, the persistent appearance of damp patches in a basement

heated by dry heat indicates that capillarity or wick action of the masonry in drawing moisture from the damp soil is probably the source of the dampness. Disappearance of the moisture when the breeze from a fan is directed over the surface for several hours is further evidence that the dampness is caused by capillarity.

A complication may arise when part of the moisture is the result of condensation. In such cases, additional examination of the damp area is desirable to determine the cause of the moisture. Evaporation of moisture from a portion of the floor surface or condensation on it will be retarded by covering the area with a rubber mat (preferably at least 3 by 3 ft). If the surface of the floor so covered remains dry after several days, condensation and not capillary transmission is one of the causes of dampness; whereas, if the area under the mat becomes damp or remains damp after surrounding areas have dried, capillarity contributes to the dampness.

Condensation of moisture from the air takes place during warm, humid weather. Usually it disappears completely during cool weather or when the humidity is low. Thus, dampness from condensation may appear and disappear within a few days, as outdoor air temperatures increase and decrease. Any one of the following tests will indicate whether or not condensation is the cause of moisture:

1. Embed a thin sheet of bright metal, metal foil, or glass, 6 in. square or larger, in plaster of paris on an area of the floor or wall that normally is damp, the plaster between the sheet and the floor or wall being made as thin as practicable. If moisture collects on the surface when the surrounding area becomes wet, condensation is one of the causes of the dampness. If the surface remains dry, condensation is not the cause.

2. Place a thermometer in contact with a damp portion of the floor or wall and cover with several layers of heavy woolen cloth or blanket so that the temperature of the thermometer will approximate that of the masonry. Another thermometer should be hung in the shade outdoors where it will be fully exposed to free circulation of the air. Both thermometers should be read during the hottest part of each day for several days. If possible, the relative humidity of the outdoor air should be determined at the same time; if not, the lowest value for the day as reported by the nearest Weather Bureau station can be used. When the basement is damp for several days, it may be concluded that condensation contributes to the dampness if the difference between the temperature of the outdoor air and the temperature of the basement walls or floor is equal to or greater than the temperature differences listed below for the corresponding listed values of the relative humidity.

Temperature difference °F	Relative humidity of air outdoors percent
3	90
6	80
10	70
14	60
20	50
26	40

III. CONDENSATION

1. Conditions Contributing to Condensation in Basements

A basement is usually built of masonry, which forms the walls and floor, with large areas in contact with the ground. The temperature of a large proportion of the wall and floor is, therefore, greatly influenced by the ground temperature, which changes slowly and at a considerable depth remains approximately constant throughout the year. Temperatures at points more than 2 or 3 ft below the ground surface are likely to vary by only a few degrees from the annual mean temperature of the locality. A basement floor and wall is likely to be cooler than the outdoor air in summer, while the temperature and humidity of the air with which basements are ventilated change daily and sometimes hourly. The weather, then, causes many basements to be alternately dry and damp in summer. Those which are exceptionally cool may be continually damp, and those which are hot may be dry. Dampness from condensation rarely occurs in the winter, both because the ground is warmer than the air during that season and because heating devices are usually in operation.

The combustion of fuels containing hydrogen, such as gas, kerosene, or other fuel oil, generates water vapor. The products of combustion from devices burning these fuels will, therefore, cause condensation unless they are conducted outside of the house by a suitable chimney or vent.

2. Remedies for Condensation

(a) Complete Ventilation

Ordinary dwelling houses can usually be dried inside simply by "airing out", which means the opening of windows and doors to allow the wind to blow through. The air, being comparatively dry, takes moisture from the damp interior walls and furnishings, while at the same time it warms them so that they no longer tend to collect moisture. Basements can also be dried out by this method if the area in contact with the ground is not too great or if the surrounding ground is so dry that its heat capacity and heat conductivity are both comparatively low. Under these conditions, it may be possible to introduce enough heat into the basement by ventilation to maintain the floor and furnishings above the dew point at all places and at all times so that condensation will not occur. On the other hand,

such ventilation, by increasing the volume of air and vapor passing over the surface, may increase the amount of moisture condensed on the walls and floors, especially during warm and humid weather.

(b) Selective Ventilation

Some householders open windows during the day in hot sunny weather and close them at night or on cool days and when it is raining. This is undoubtedly good practice as far as houses are concerned, but may not be the best procedure to follow for basements, because basement wall and floor temperatures are not raised quickly by ventilation.

On warm sunny days when the absolute humidity is high water may condense on the walls and floors in basements which are ventilated.

At night, or on cool days, if basements are ventilated, the tendency will be for moisture to evaporate and pass outdoors as vapor, even though rain is falling, provided the temperature of the walls and floor is above the outdoor dew point. However, evaporation from the basement walls and floor tends to cool them so that in some cases the heat gain of the basement from the surrounding ground and from the house above usually is insufficient to maintain this kind of drying process.

The method of selective ventilation is often ineffective and, even if effective, is a nuisance on account of the necessity for frequent opening and closing of windows.

(c) Heating

Sufficient heat will dry any basement. Heat from domestic hot-water heaters, operating continuously during the summer, may solve the condensation problem im many basements. The fact that heat can prevent condensation and can evaporate moisture which may come through walls by capillary action or otherwise is a strong argument for not insulating these heating devices too effectively.

(d) Insulation

Since condensation occurs on any surface with a temperature below the dew point of the surrounding air, it cannot be prevented by coating the surface with paint, varnish, paper, or other thin material. But, if the wall is insulated so that the temperature of the inside surface closely follows that of the air, condensation will not occur on the surface. While insulation is helpful in any position in or on the wall or floor, it is most effective in minimizing condensation resulting from sudden changes in outdoor air temperature if it is near the inner surface.

The insulating value of a layer of gravel or crushed stone

on the outside of a wall or under a floor is comparatively small in itself but the presence of this layer, by permitting rapid drainage, may hasten the drying of the soil surrounding the basement. Dry soil has a lower heat capacity and a higher insulating value than wet soil. Therefore, the insulating effect achieved indirectly by the use of a layer of porous fill may assist in reducing dampness in basements.

One way of insulating a basement is by means of interior finishes. Various combinations of materials may be used for such finishes, but care should be taken to avoid the use of materials that may be damaged by moisture unless these are suitably protected.

(e) Dehumidification

It is possible to prevent condensation in a basement by removing some of the moisture from the air, thus lowering its humidity and the dew point. Moisture may be removed by refrigeration, as in summer air conditioning, or by means of absorptive substances sold for the purpose.

Water vapor has a tendency to condense on the coldest object in the vicinity, so that, if the cold evaporator of a refrigerating machine is exposed in a basement, condensation can be expected to occur on it rather than on the walls or floor. However, the equipment necessary to accomplish this is likely to cost several hundred dollars installed, more than most householders can spend to obtain a dry basement. Moreover, the cost of power required to operate the refrigerator and of repairs may not justify the added usable space made available through drying the basement.

Some materials, such as calcium chloride, lithium chloride, silica gel, and activated alumina have the power to absorb water vapor from the air. Supplies of calcium chloride, trays, and directions for its use can be obtained from building supply dealers. This salt customarily is sold in 100-lb bags and 400-lb sealed drums at a cost of approximately 3 cents per lb. As the salt absorbs moisture from the air, it dissolves and forms a solution which must be disposed of. If this solution is emptied into drains, care should be taken to flush them well as the solution is highly corrosive to metal and is somewhat injurious to concrete. The absorption process generates about 1,100 Btu of heat per lb of water absorbed.

Silica gel and lithium chloride have not attained as wide usage in basements as has calcium chloride, presumably because their absorptive powers are not as great.

During operations that liberate extraordinarily large amounts of water vapor, such as laundering, the basement should be ventilated. Clothing hung to dry in a basement will increase condensation.

3. Dampness in Ground Floors and Floors Above Crawl Spaces

The problem of preventing dampness in ground floors laid directly on the soil is similar to that of preventing dampness in basements. Ground floors for living quarters should be provided with drainage, a barrier against capillary rise of moisture, and thermal insulation. Methods of construction which are likely to be effective are illustrated in figures 1(d) and 1(e). Floors so constructed ordinarily will serve as a satisfactory base for any type of floor finish. More effective types of thermal insulating materials, such as hollow masonry units, vermiculite aggregate concrete, Foamglas, etc., may be substituted for the porous fill shown in figure 1(d); insulation along the edge of the slab always should be provided. [2]

Inquiries are occasionally received about preventing dampness in the closets of first floor apartments above crawl spaces. In such cases, the closet floor and part of its contents are probably losing heat to the crawl space, thereby being cooled below the dew point of the air in the closet. The application of heat can raise the temperature above the dew point. Increased ventilation with warm air from the living space may possibly be sufficient. An electric light burning continuously would probably be helpful, especially where it shines directly on the floor.

A layer of insulation, such as fiber insulating board, at least 1 inch thick, laid on the floor of the closet would be useful in retarding the heat loss to the basement. Such a layer should be covered with a vapor barrier, otherwise the insulation might become wet from condensation within whenever the temperature is below the dew point. This would eventually cause the floor to rot. A rubber mat or asphalt base floor coverings are suitable for use as a vapor barrier if well fitted and cemented at the edges. Loose materials should not be permitted to lie directly on the closet floor since they would also act as insulation.

Crawl spaces under floors can usually be warmed sufficiently by continuous ventilation to prevent excessive dampness. The Federal Housing Administration requires the provision of 1 sq ft of opening for each 15 lin ft of basement wall for dwelling houses with wood floors over crawl spaces. [3]

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[2] NBS BMS 103 Measurements of Heat Losses from Slab Floors. Sold by the Superintendent of Documents, Washington 25, D. C. for 10 cents.

[3] FHA Minimum Requirements for Rental Housing ~~Projects,~~ submitted under Title ~~VI,~~ Section 608, National Housing Act, May 26, 1942 FHA Minimum Requirements for New Dwellings (Issued separately for each state.)

IV. PENETRATION OF WATER INTO BASEMENTS

Treatments to prevent the penetration of water through basement walls and floors, because of their slight insulating value, will have little effect on the conditions which may produce condensation within a basement. Since treatments for waterproofing are likely to be expensive, the fact should be firmly established that dampness in a basement is caused by leakage and not condensation before planning treatments to correct dampness.

1. Leakage Through Openings

(a) Causes

Unless the soil surrounding the basement is porous and well drained, ground water is likely to come in contact with basement walls for short periods immediately following rains; in rare instances the ground-water level may even be above the basement floor. Basement walls and floors, or the junctions between, often have openings large enough (much larger than the capillary pores in masonry materials) for water under pressure to seep through if the pressure is applied for a period of a few minutes to an hour. Openings may result from foundation movement, imperfections in workmanship, or expansion and contraction produced by changes in temperature or humidity.

(b) Remedial Measures

(1) Drainage

Frequently examination shows that the amount of water allowed to accumulate on the outside of basement walls and floors is unnecessarily large. Rainwater from roofs, collected by gutters and downspouts, is permitted to empty near the walls, where it collects and stands against them. Water from roofs should be diverted away from the basement by means of drains or splash blocks.

The slope of the yard surrounding a building often causes surface water to accumulate against the basement wall. Regrading away from the wall is sometimes all that is necessary to eliminate excessive leakage. The ground surrounding a basement should be sloped at least 1/4 in. per foot for a distance of 8 to 10 ft away from the wall. If this is impracticable, walkways and gutters of masonry or concrete may be constructed to collect the surface water and divert it away from the basement.[4]

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4 An excellent discussion of surface and subsoil drainage is included in Farmers' Bulletin No. 1572, "Making Cellars Dry", sold by the Superintendent of Documents, Washington 25, D. C., for 5 cents.

Where there is a tendency for the ground water to remain above the bottom of the basement floor for long periods, an underground tile drain should be provided at an elevation below the basement floor. If the structure is on a hillside, the installation of a drain along the high side only may be sufficient; otherwise, it is better for the drain to surround the structure. The drain should be sloped gently, the water being led to a sewer or other outlet, which must be open at all times. The drain tile should be surrounded with coarse gravel or crushed stone so that the water may pass quickly into the tile, but the joints should be covered with strips of tar paper, wire mesh or burlap to retard the entrance of soil during the backfilling of the excavated soil.

If an outside drain is impracticable, some relief from flooding may be obtained by placing a drain along the inside edge of the footing, as shown in figure 1(c). A trough may be constructed to collect the water passing through the basement walls, the water being led to a sump provided with a drain or with an automatic float-controlled pump. As an extra precaution, walls sometimes are built with a specially designed structural clay tile which is shaped to collect water passing through the outer surface and to allow it to travel downward inside the wall to a drain at the footing.

(2) Outside Waterproofing Treatments

Waterproofing treatments applied to the outside walls of basements are generally more effective and durable than similar treatments applied to the inside.

Membrane waterproofing.--The most effective and durable waterproofing for basement walls and floors in common use is a bituminous membrane. Such a membrane, if made continuous within the floor structure and on the outside of the basement wall, as shown in figure 1(b), is effective against water under a continuing pressure.

The membrane waterproofing consists of three or more alternate layers of hot asphalt or coal tar and cotton fabric or felt. The surfaces to be waterproofed should be clean and free from pits or sharp projections. Sometimes it may be necessary to apply a coat of portland-cement mortar to the faces of masonry walls to obtain a smooth surface as a base for the membrane. A bituminous priming coat is first applied, then a hot mopping of bitumen, followed by the fabric and another hot mopping, until the desired number of plies is in place. Adjacent strips of the fabric should be lapped at least 3 in. Sometimes the exterior of the membrane is protected against abrasion by a layer of portland-cement stucco, clay brick, or concrete.

Bituminous coatings.-- When conditions are less severe, and the walls are not subjected to water under pressure for long periods, the exterior of walls may be coated first with a

cement mortar and then with a bituminous material without fabric. The surface to receive the bituminous coating should be smoothed in the same manner as for the bituminous membrane. The coating may be of hot asphalt or coal tar, a water emulsion of asphalt, or a trowel coating of bituminous mastic. Of these, the hot application provides the best protection. Basement walls, if cracked from settling, may be waterproofed with a bituminous membrane, which is more likely to remain intact than a bituminous coating without fabric.

Cement-mortar coatings.--Perhaps the most commonly used protection on the outside of basement walls consists of one, or preferably two, coats of cement mortar, each 3/8 in. thick (figure 1(a)). Before these are applied, the masonry should be thoroughly cleaned by removing grease, oil, and loose particles. The walls should be moistened, preferably several hours before the next operation, and then scrubbed with a grout of portland cement and water, using a stiff broom or scrub brush. The first coat of mortar should be applied while the grout is still soft. Before the first coat hardens it should be scratched with a coarse broom or other tool to provide a roughened surface for the second coat. Mortar should be a mixture of 1 part of portland cement and 2-1/2 parts of sand by volume. Mortar should be kept damp 3 or more days after application.

Cracks in monolithic concrete walls may be sealed by cutting a groove along the crack at least 1 in. deep and 1 in. wide; the edges of the cut should be of full depth. After the surfaces have been wetted, a cement grout should be scrubbed into the groove and then a cement mortar of stiff consistency should be packed into the opening.

Although the cement-mortar coatings will greatly retard the leakage of water through walls and will effectively seal large openings, any movement of the foundation or other disturbance of the walls may tend to rupture them.

Cement-grout coatings.--Very small openings in masonry walls may be sealed by applying a grout mixture of 1 part portland cement, 1 part fine sand, and water. The grout should have the consistency of thick cream and should be applied by means of stiff fiber brushes after the larger openings have been filled with cement mortar and the surface of the masonry has been prepared in the same manner as for the cement mortar coatings. At least two, and preferably three, coats should be applied, allowing each coating to harden before applying the next one. Grout coatings are more permeable to water under pressure than are mortar coatings, and like mortar coatings, their effectiveness is limited in that movements of the walls may tend to crack them.

Cementitious coatings containing powdered iron.--Many waterproofing contractors prefer to use powdered iron and an oxidizing agent, such as sal-ammoniac, in portlant-cement

mortar or grout coatings. Such treatments are known to be effective but the results of laboratory tests have failed to disclose that they are more effective than similar coatings not containing powdered iron.

Directions for applying cementitious waterproofings containing powdered iron are usually given on the container for the iron and its oxidizing agent; the procedures generally recommended are similar to those given above for applying cement mortars and grouts.

Liquid coatings.--Various thin liquid coatings of waxes, varnishes, paints, water repellent soaps, and bituminous materials have been proposed for use on the exterior of basement walls. Experience indicates that these are not as effective nor as durable as the coatings previously discussed. In general, cementitious coatings are more effective as waterproofings than those containing oils, resins, or waxes.

(3) Inside Waterproofing Treatments

Plugging leaks.--If water under pressure is seeping through openings or cracks in a concrete wall, it will be necessary to stop the leaks before proceeding further with inside treatments. Usually this can be done by cutting out the concrete to a depth of 1 or 2 in. immediately surrounding the opening, and filling the space with a mixture of high-early-strength portland cement and sand mixed with a solution of calcium chloride, which accelerates the hardening. The amount of calcium chloride will depend upon the cement, but usually a quantity equal to approximately 5 percent by weight of the cement will sufficiently accelerate the hardening. A mixture consisting of 1 part portland cement and 1 part sand and having the consistency of putty can be pressed into the opening and held there by means of a form or a small board until it is sufficiently hardened to stay in place. If the water pressure is so high that leaks cannot be plugged in this manner, it can be relieved by passing a pipe through the wall. This may be capped later.

Cement-mortar coatings.--Leakage through unit-masonry walls usually can be stopped by applying two coatings of cement mortar, each 3/8 in. thick, to the interior surfaces in the manner described for the outside treatments (figure 1(c)). These coatings should preferably be of 1 part of portland cement and 2 to 2-1/2 parts by volume of sand.

Leakage through cracks in concrete floors often can be stopped by covering the entire surface with a layer of mortar or concrete. The surface of the floor should first be cleaned and moistened. A few minutes before placing the new concrete it should be scrubbed with neat cement grout. The surfacing material should be placed in one operation and should be at least 3/4 in. thick, using as dry a mixture as can be placed conveniently.

Cement-grout coatings.--Small leaks in masonry walls can sometimes be sealed by means of brush applications of cement-grout applied in the manner described for outside treatments. Cement-grout coatings are more permeable than cement-mortar coatings and cannot be relied upon to stop the leakage of water under high pressure.

Cementitious coatings containing powdered iron.--As an alternate to the use of portland-cement mortar or brush coatings, similar treatments containing powdered iron, described under outside waterproofing treatments, may be substituted.

2. Penetration by Capillarity

(a). Causes

If the outside surface of basement walls and floors in contact with damp soil are not effectively waterproofed, moisture may pass or be drawn through the masonry to the inside of the basement by capillarity. Often, the amount of moisture is so small that it is carried away by evaporation in the air, and the walls and floors appear to be dry. However, if the air in the basement should approach saturation with water vapor, evaporation will no longer take place and moisture will appear on the floor or walls. It is difficult to determine whether such moisture is produced by capillarity or by condensation, unless the surface area is tested for condensation of moisture by one of the methods described in section II, Causes of Dampness and Methods of Determining the Sources.

The penetration of small amounts of moisture by capillarity may not be objectionable in a basement unless it is used for living quarters or the floor and walls are covered with materials impervious to air such as oil paints or linoleum. Such interior finishes or coverings will retard or prevent evaporation and thus be damaged by the accumulated moisture.

(b) Remedial Measures

(1) Drainage

The provisions for draining surface and underground water away from basements, previously described under drainage, will be helpful in reducing moisture transmission by capillarity. A filling of porous material under the basement floor and adjacent to the basement walls will greatly minimize dampness resulting from absorption by capillarity. Waterproofed sheathing paper or a coating of asphalt or tar under the floor retards the capillary rise of moisture and is likely to afford adequate protection if used as illustrated in figure 1(a and d).

(2) Integral Waterproofing

The addition of water-repellent substances to concrete or mortar tends to reduce the absorption of moisture by capillarity, but increases slightly their permeability to water under pressure. The most widely used of the effective water-repellent admixtures for concrete contain calcium stearate or ammonium

stearate as the water-repellent substance. The "waterproofed" portland cements, which are readily available from building supply dealers, contain a uniformly dispersed water repellent such as calcium stearate and may be used conveniently instead of an admixture and an ordinary cement.

(3) Bituminous Waterproofing

Bituminous membranes or coatings on walls and floors similar to that shown in figure 1(b) are effective in preventing moisture transmission by capillarity. The coatings or membranes should be either embedded in the concrete or applied to the outside surface of the basement. Bituminous coatings applied to the inside walls of basements are likely to blister or peel.

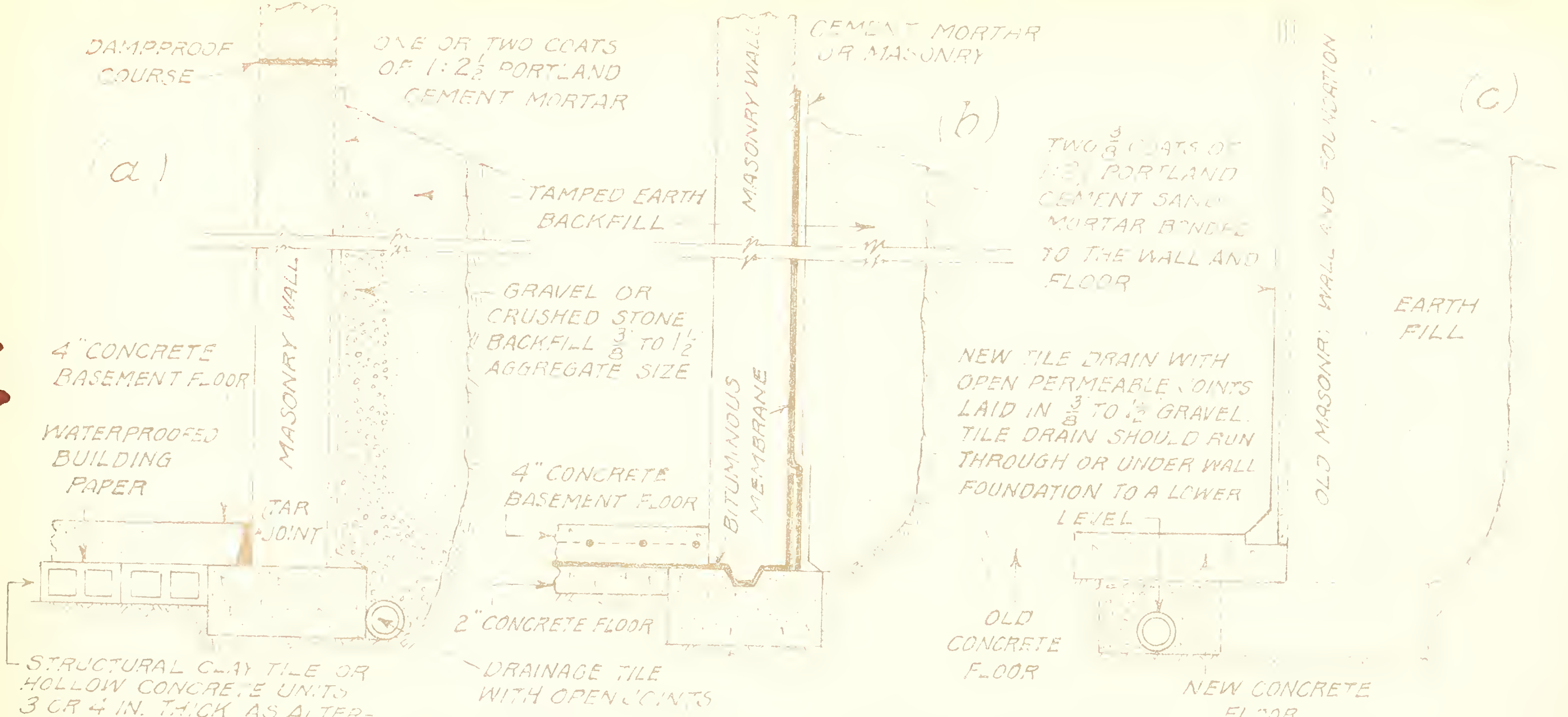
V. SUMMARY

Dampness in basements may be the result of condensation or penetration of water through masonry by leakage or capillarity.

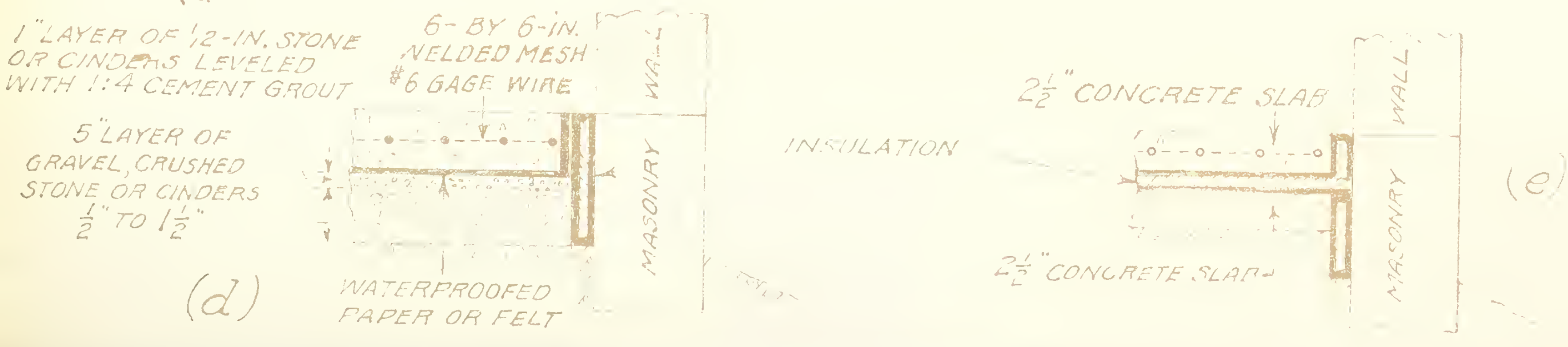
Condensation in a basement can be prevented (a) by heat in conjunction with ventilation, (b) by reducing the humidity as by means of an air conditioner or a moisture absorbing apparatus. Condensation often can be sufficiently reduced by ventilation, especially by selective ventilation when conditions are favorable. Condensation on a selected surface such as a wall or a floor can be prevented by means of panels supported at a slight distance from such surfaces as by means of furring strips or sleepers. Ventilation is essential to prevent condensation in a basement or other space in which water vapor is set free, as by cooking or washing.

Leakage can be prevented by the provision of adequate drainage or by waterproofing either the inner or exterior surfaces. Membrane waterproofing applied to exterior surfaces are resistant to water under long-sustained pressure; other bituminous coatings may give adequate protection against occasional exposure to dampness. Coatings of cement mortar or cement grout may be applied either to the exterior or the inner surfaces of basement walls to minimize leakage. Properly applied mortar coatings are likely to be more effective than coatings of grout.

Moisture that penetrates masonry by capillarity is not often excessive where adequate provisions are made for drainage of the surrounding soil. Membrane waterproofings on exterior surfaces of masonry are effective barriers to capillary penetration; bituminous coatings and coatings of cement mortar containing integral water repellents usually provide a sufficient safeguard against penetration of water by capillarity.



BASEMENT WALLS AND FLOORS



INSULATED AND WATERPROOFED GROUND FLOORS